The use of eco-efficiencies within a Cleaner Production framework in assessing the overall greenness of a company – A developing country (Zimbabwean) perspective concentrating on food manufacturing companies.

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***Abstract*---** This research seeks to develop an integrated system of EECP options, indices and techniques with less resource usage intensities and higher operational efficiencies for the food manufacturing industry in Zimbabwe. Specifically the research will seek to conserve raw materials as there will be reduced waste accumulation, eliminate contact with toxic raw materials by substituting or disposing them, reduce the quantities and toxicity of wastes and emissions, quantify and stratify wastes generated in Zimbabwean industries, develop an EECP based framework for measuring the greenness of a company. The concomitant result is that the working environment will be cleaner and safe thereby reducing health hazards and will also be more productive and profitable.

***Keywords*--** Eco-efficiency based Cleaner Production, material intensity, recyclability, service intensity, and resource productivity.

I. Introduction To Eco-Efficiency Based Cleaner Production (EECP)

THE EECP concept, involves the merging of advanced technologies as well as the environmentally friendliest strategy. EECP means the continuous application of an integrated preventive environmental strategy to processes, products and services, to increase efficiency and to reduce risks to human being and the environment [1].

EECP requires applying know-how, improving technology and changing people's attitudes in the way people conduct their businesses. This concept is applied both to the production process and to the products, to preserve raw materials and energy, to eliminate toxic materials, and to reduce the quantity and toxicity of all emissions and wastes before they leave the process.

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For products, the strategy focuses on reducing impacts along the entire life cycle of the product, from raw materials extraction to ultimate disposal of the products. . Eco-efficiency is a management concept that allows companies to search for environmental improvements in the ecological, economical and social fronts [6].

The environmental improvements must offer economic competitive advantage to companies implementing this novel concept [7]. In this perspective, cleaner production is a holistic environmental management strategy, [10] and hence it is the brief of this work to attempt to provide a holistic EECP approach to solving the environmental burden of Zimbabwean industries.

The World Business Council for Sustainable Development [1] lists seven key performance indices for eco-efficiency:

- Reduce material intensity of goods and services
- Reduce energy intensity of goods and services
- Reduce the dispersion of any toxic material
- Enhance the recyclability of materials
- Maximise the sustainable use of renewable resources
- Extend the durability of products
- Increase the service intensity of goods and services.

Eco-efficiency goes beyond resource use and pollution reduction by emphasising value creation for business and society at large, while providing for competitive needs. By increasing value for the goods and services it creates, business will maximise resource productivity, gain bottom-line benefits, and reward shareholders, rather than simply minimise wastes or pollution.

II. Research Justification

In Zimbabwe, there is pollution in the plants due to waste from raw materials, processes and products. A number of potential hazards are associated with handling these wastes. Some wastes are not toxic and do not irritate, but they influence the body on a more subtle level to produce cancer as they maybe carcinogenic. There is need to reduce the exposure

to humans to toxic chemicals in the raw materials and to control pollution levels. The design of EECP Abatement systems and more environmentally benign industrial processes will minimize waste and emissions and improve efficiency. Investing in process modification as a EECP option prevents pollution and reduces resource consumption. EECP is a strategy positioned at the interface of environmental protection and productivity. EECP program can lessen the exposure of employees to harmful substances, thus decreasing risk and saving money [10].

Commercial wastes generated by the Zimbabwean industrial activities factory include [5].

- Waste water from product manufacture, sanitation and cleaning.
- Coal rubble generated from firing coal boilers for steam generation.
- Emissions from the burning of coal and vehicular emissions from the delivery vehicles going into the market.
- Used oil from vehicles.
- Poltytethylenetetraphtalate (PET) and Polyvinylchloride (PVC) through discarding of reject plastic material used for packaging of product.
- Metallic waste generated from engineering activities.
- Electronic waste from use of computers and printers
- Organic waste such as wood, swept soil and waste food from the staff canteen.
- General waste such as newspapers, paper, magazines, dead flowers, boxes, paper
- Waste from office areas, toilets and corridors; and
- Kitchen waste from the staff canteen.

The amount of waste generated can be reduced if the company adopts cleaner production (EECP) strategies. According to the Asian Development Bank, There is no longer any need to prove that EECP can improve the performance of firms and projects in Asia. EECP has been widely implemented in Asia realizing millions of dollars in savings for those companies who have whole heartedly implemented the philosophy [9].

III. EECP A PARADIGM SHIFT

The EECP aspect requires a new way of thinking about processes and products, and about how they can be made less harmful to humans and the environment. Elimination of dust creation in the first place through modification of the disperser feeding process as a EECP option ensures a clean and safe working environment. There will be reduced pollution due to dust accumulations and a corresponding decrease in raw material wastes which fly out as dust and as spillages. Health risks to the operators are reduced substantially and skin contact with hazardous chemicals and inhalation of dust is extensively eliminated.

A new technology through the design of a material handling system for the feeding process can be adopted as a cleaner production option. Material handling is defined as the movement, storage, protection and control of materials throughout the manufacturing and distribution process including their consumption and disposal [3]. According to OSHA 2236, 2002, the efficient handling and storing of materials are vital to industry as the improper handling and storing of materials often result in costly injuries.

IV. EECP BENEFITS

Zimbabwean companies can benefit from eco-efficiency by having [5]:

- safer food
- better input control
- better output control
- better process control
- reduced costs and improved profits
- reduced risk of liability

The main techniques of EECP include improving material and energy efficiency of products, reduction of environmental and human health related risks, and processes that are designed for the environment and increased sustainability [2]. EECP therefore embraces cleaner production concepts such as efficient use of raw materials, pollution prevention, source reduction, waste minimisation, and internal recycling and reuse. It captures the idea of pollution reduction through process change as opposed to the earlier end-of-pipe approaches [1].

V. HYPOTHESIS

The design of EECP Abatement systems and more environmentally benign industrial processes plants as an EECP option will lead to a greener corporate image.

In a world of increasing demand for depleting natural resources, posterity will see a focus on resource use efficiency and a major global effort on extracting more from less. As a measure of EECP, the WBSCD has further proffered an empirical definition of eco-efficiency: Eco Efficiency = Product or Service Value / Environmental Influence Generally Product or Service Value has to do with:

- Mass or number of products or services produced or sold and
- Net sales,Environmental Influence has to do with
- Energy consumption
- Material consumption
- Net water consumption
- Greenhouse gas emissions; and
- Ozone depleting substance emissions.

The greenness of a company can be measured by its environmental influence as defined above. Further the WDSDC, 1992 further proffers other indices by which the greenness of a company can be verified:

- Company culture
- Training:
- Reconnaissance:
- Management tools
- Research &Development (R&D) for eco-efficiency
- Design for eco-efficiency:
- Production and eco efficiency:

VI. EECP Options

In the Cleaner Production concept, industrial processes can often be improved in ways that not only reduce the amount of waste, and therefore pollution, but also save or make money for the company. According to UNEP, 1989, EECP is the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase eco-efficiency and reduce risks to humans and the environment**.** Thus in addition to life cycle impacts, EECP also addresses health and safety concerns and emphasizes risk reduction. In this perspective, EECP is a holistic environmental management strategy [10], which could further fall under one of the following categories as listed below:

- Housekeeping
- Management and personnel practices.
- Process optimization
- Raw material
- New technology
- New product design
- Recovery of useful by-products / resources
- Onsite recycling and reuse

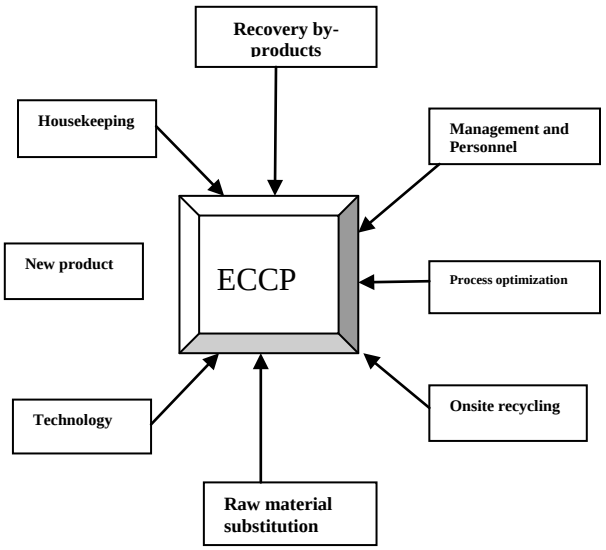

Fig. 1 Categories of EECP Options

VII. EECP And Pollution Control

The key difference between pollution control and EECP is one of timing. Pollution control is an after-the-event, 'react and treat' approach, whereas EECP reflects a proactive, 'anticipate and prevent' philosophy. Prevention is always better than cure.

This does not mean, however, that 'end-of-pipe' technologies will never be required. By using a EECP philosophy to tackle pollution and waste problems, the dependence on 'end-of-pipe' solutions may be reduced or in some cases, eliminated altogether.

EECP can be and has already been applied to raw material extraction, manufacturing, agriculture, fisheries, transportation, tourism, hospitals, energy generation and information systems.

It is important to stress that EECP is about attitudinal as well as technological change. In many cases, the most significant EECP benefits can be gained through lateral thinking, without adopting technological solutions. A change in attitude on the part of company directors, managers and employees is crucial to gaining the most from EECP.

Applying know-how means improving efficiency, adopting better management techniques, improving housekeeping practices, and refining company policies and procedures [4]. Typically, the application of technical know-how results in the optimisation of existing processes. changing the final product or developing alternative products;

TABLE I
A Possible Range Of Eecp Options

	Types of EECP ***options***
Housekeeping	Improvements to work practices and proper maintenance can produce significant benefits. These options are typically low cost.
Process optimisation	Resource consumption can be reduced by optimizing existing processes. These options are typically low to medium cost.
Raw material substitution	Environmental problems can be avoided by replacing hazardous materials with more environmentally benign materials. These options may require changes to process equipment.
Technology	Adopting new technologies can reduce resource consumption and minimise waste generation through improved operating efficiencies. These options are often highly capital intensive, but payback periods can be quite short.
New product design	Changing product design can result in benefits throughout the life cycle of the product, including reduced use of hazardous substances, reduced waste disposal, reduced energy consumption and more efficient production processes. New product design is a long-term strategy and may require new production equipment and marketing efforts, but paybacks can ultimately be very rewarding.

TABLE II
Opportunities for Improvement

	Opportunities	**Potential Resource saving**		
		Water	**Energy**	**Chemical**
1	Optimising CIP system	✓	✓	✓
2	Install solar water heaters to the canteen		✓	
3	Re-routing of steam delivery system via a shorter path to the plant		✓	
4	Repair pressure Leaks on the 10 bar compressor Line		✓	
5	Recovery of backwash water at the water treatment plant	✓		✓
6	Replacement of Mercury lamps 400W with Metal Halide lamps 250		✓	

TABLE III
TYPICAL ECO-EFFICIENCY INDICATORS IN THE FOOD INDUSTRY

Product yield	kL product per kL raw material consumed
Water	kL consumed per kL product
Energy	kWh consumed per kL product, or MJ consumed per kL product
Wastewater	kL generated per kL product
Solid waste	kg generated per kL product

TABLE IV
KEY BEVCO PERFORMANCE INDICATORS

	CURRENT PERFORMANCE (per liter of beverage)	**TARGET PERFORMANCE (per liter of beverage)**
INPUTS		
Water	2litre	1.5litre
Electricity	0.4MJ	0.3MJ
Coal	Unknown	Unknown
OUTPUTS		
Solid Waste	3.45g	3.0g
Wastewater Volume	0.53Litre	0.3Litre
Wastewater quality	Unknown	Unknown

VIII. Repair Steam Leaks On The 10 Bar Compressor Line

A no-load test for the compressed air section is carried out for the 10 bar compressor during the weekend. The 10 bar compressor is designed with a free air delivery of 555 m^3 as per name plate details. The motor is Compressor motor is rated – 55 kW. When the load was actually measured, it was determined that the load power was at the maximum. With the air delivery of the compressor at 455m^3, the specific energy consumption of the compressor was determined at 0.12 kW/ (m^3/hr**).**

Results

Loading time (T) : 11 sec

Unloading time (t) : 13 sec

Leakage quantity : 208 m^3/hr

The evaluated compressed air leakage in the system is around 46% as compared to the design parameters of the compressor. The air leakage causes a pressure drop between the supply and end user equipment of approximately 2 bars. Compressed air leakage is nothing but waste of energy, in present case it is close to 46%. For this type of industry only a 5% leakage is acceptable. The walkabout identified that continuous air leakage is prevalent on all the pipes distributing pressure to all the packaging lines.

An opportunity exists for the company to save energy and depreciation of the compressor by arresting air leaks on the piping network. After arresting the air leakage, loading time of the compressor is anticipated to be much lower than the present scenario.

IX. Conclusion

From the foregoing synopsis, it is thus important to look at the "big picture" when considering EECP issues, rather than concentrating on the daily routines most of which can be classified as pollution control. EECP is a practical method for protecting human and environmental health, and for supporting the goal of sustainable development. The EECP methods of pollution prevention, source reduction, waste minimization and eco-efficiency necessarily inculcate better management and housekeeping; substitution of toxic and hazardous materials, process modifications by preventing, rather than the controlling pollution. EECP mandates a reduction of resource usage and heightening material and energy intensities as exemplified by this research, and a gradual shift to 'contained processes' where waste can be recycled back into the process.

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